THE ASCA HARD SERENDIPITOUS SURVEY (HSS): A PROGRESS UPDATE

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ABSTRACT

We present here a status update on the ASCA Hard Serendipitous Survey (HSS), a survey program conducted in the 2-10 keV energy band. In particular we discuss the number-flux relationship, the 2-10 keV spectral properties of the sources and of the spectroscopically identified objects.

KEYWORDS: Galaxies: active — diffuse radiation — surveys — X-ray: galaxies — X-ray: general

1. INTRODUCTION

At the *Osservatorio Astronomico di Brera* we started a few years ago the ASCA Hard Serendipitous Survey (HSS): a systematic search for sources in the $2-10$ keV energy band, using data from the GIS2 instrument onboard the ASCA satellite. The specific aims of this project are: a) to extend to faint fluxes the census of the X-ray sources shining in the hard X-ray sky, b) to evaluate the contribution to the Cosmic X-ray Background (CXB) from the different classes of X-ray sources, and c) to test the Unification Model for AGNs.

This effort has lead to a pilot sample of 60 sources that has been used to extend the description of the number-counts relationship down to a flux limit of $\sim 6\times10^{-14}$ erg cm^{-2} s^{-1} (the faintest detectable flux) resolving *directly* about 27% of the (2 - 10 keV) Cosmic X-ray Background (CXB), and to investigate their X-ray spectral properties (Cagnoni, Della Ceca and Maccacaro, 1998; Della Ceca et al., 1999).

Recently the ASCA HSS has been extended: we discuss here this extension and the main results obtained so far.

2. THE ASCA HSS SAMPLE

The data considered for the extension of the ASCA HSS were extracted from the public archive of 1629 ASCA fields (as of December 18, 1997). The fields selection criteria, the data preparation and analysis, the source detection and selection and the computation of the sky coverage are described in detail in Cagnoni, Della Ceca and Maccacaro (1998) and Della Ceca et al. (1999).

The 300 GIS2 images adequate for this project have been searched for sources with a signal-to-noise (S/N) ratio greater than 4.0 (a more restrictive criterion than that adopted in Cagnoni et al., (1998) where a $S/N \geq 3.5$ was used). A sample of 189 serendipitous sources with fluxes in the range $\sim 1 \times 10^{-13} - \sim 7 \times 10^{-12}$ erg cm^{-2} s^{-1}, found over a total area of sky of ~ 71 deg^2, has been defined. Full details on this sample will be reported in Della Ceca at al., (2000).

3. THE 2-10 KEV LOGN(>S)−LOGS

In Figure 1 we show a parametric (solid line) and a non parametric (solid histogram) representation of the number-flux relationship obtained using the new ASCA HSS sample of 189 sources.

Also shown in Figure 1 (cross at $\sim 3 \times 10^{-11}$ ergs cm^{-2} s^{-1}) is the surface density of the extragalactic population in the Piccinotti et al., (1982) HEAO 1 A-2 sample (as corrected by Comastri et al., 1995) and the surface density of X-ray sources as determined by Kondo (1991) using a small sample of 11 sources extracted from the Ginga High Galactic Latitude survey (filled triangle at $\sim 8 \times 10^{-12}$ ergs cm^{-2} s^{-1}). The surface densities represented by the filled dots at $\sim 1.2 \times 10^{-13}$, $\sim 1.8 \times 10^{-13}$, and $\sim 3.0 \times 10^{-13}$ ergs cm^{-2} s^{-1} are the results from the ASCA Large Sky Survey (Ueda et al., 1999); the filled dot at $\sim 5 \times 10^{-14}$ ergs cm^{-2} s^{-1} has been obtained by Georgantopoulos et al. (1997) using 3 deep ASCA GIS observations; the filled dot at $\sim 4.0 \times 10^{-14}$ ergs cm^{-2} s^{-1} has been obtained from Inoue et al. (1996) using data from a deep ASCA observation. Finally, the filled square at $\sim 5.0 \times 10^{-14}$ ergs cm^{-2} s^{-1} has been obtained by Giommi et al. (1998) using data from the BeppoSAX deep surveys. As it can be seen, our determination of the number-flux relationship is in very good agreement with those obtained from other survey programs.

The LogN(>S)-LogS can be described by a power law model $N(>S) = K \times S^{-\alpha}$ with best fit value for the slope of $\alpha = 1.63 \pm 0.09$; the dotted lines represent the $\pm 68\%$ confidence intervals on the slope. The normalization K is determined by rescaling the model to the actual number of objects in the sample and, in the case of the "best" fit model, is $K = 9.65 \times 10^{-21}$ deg^{-2}. At the flux limit of the survey ($\sim 7 \times 10^{-14}$ ergs cm^{-2} s^{-1}) the total emissivity of the resolved objects is ~ 10 keV cm^{-2} s^{-1} sr^{-1}, i.e. about 30% of the 2-10 keV CXB. A flattening of the number-flux relationship, within a factor of 10 from our flux limit, is expected in order to avoid saturation.

4. THE 2-10 KEV SPECTRAL PROPERTIES OF THE SOURCES

To investigate the spectral properties of the sources in the 2.0 - 10.0 keV energy range we defined the Hardness Ratio, $HR2 = \frac{H-M}{H+M}$, where H and M are the observed (GIS2 + GIS3) net counts in the 2.0-4.0 keV and 4.0-10.0 keV energy band respectively (see Della Ceca et al.,1999 for details). In Figure 2a, for all sources, we plot the HR2 value versus the GIS2 count rate; we have also reported the flux scale obtained assuming a count rate to flux conversion factor appropriate for a power

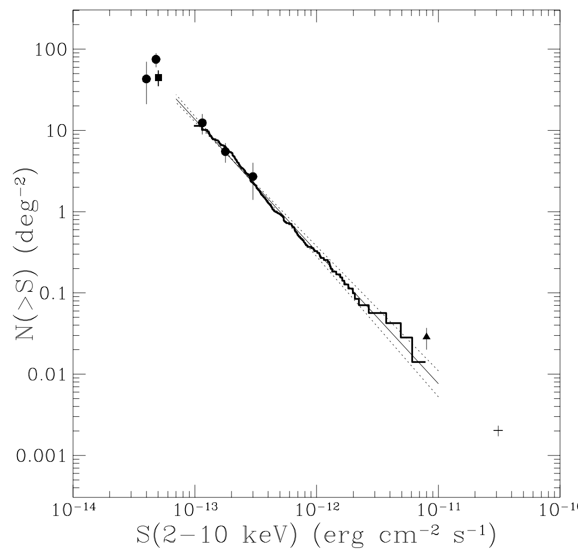

FIGURE 1. The 2-10 keV logN(>S)-logS. See section 3 for details.

law model with $\alpha_E \sim 0.6$, the median energy spectral index of the sample. The HR2 values are then compared with those expected from a non absorbed power-law model with α_E ranging from -1.0 to 2.0. It is worth noting the presence of many sources which seem to be characterized by a very flat 2-10 keV spectrum with $\alpha_E \leq 0.4$ and of a number of sources with "inverted" spectra (i.e. $\alpha_E \leq 0.0$).

A flattening of the mean spectrum of the sources with decreasing count rate is clearly evident. If we divide the sample into two subsamples (the bright sample is defined by the 60 sources with a count rate $\geq 4.3 \times 10^{-3}$ cts s^{-1}, while the faint sample is defined by the remaining 129 sources), than the fraction of sources with $\alpha_E \leq 0.4$ ($\alpha_E \leq 0.0$) is $15 \pm 5\%$ ($8 \pm 4\%$) in the bright sample and becomes $43 \pm 7\%$ ($18 \pm 4\%$) in the faint sample. These objects with very flat spectra could represent a new population of very hard serendipitous sources or, alternatively, a population of very absorbed sources as expected from the CXB synthesis models based on the AGN Unification Scheme.

5. THE SPECTROSCOPICALLY IDENTIFIED SAMPLE

Up to now 47 sources have been spectroscopically identified. The optical breakdown is the following: 1 star, 5 cluster of galaxies, 5 BL Lac objects, 33 Broad Line Type 1 AGNs and 3 Narrow Line Type 2 AGNs. However we stress that this small sample of identified objects is probably not representative of the whole population.

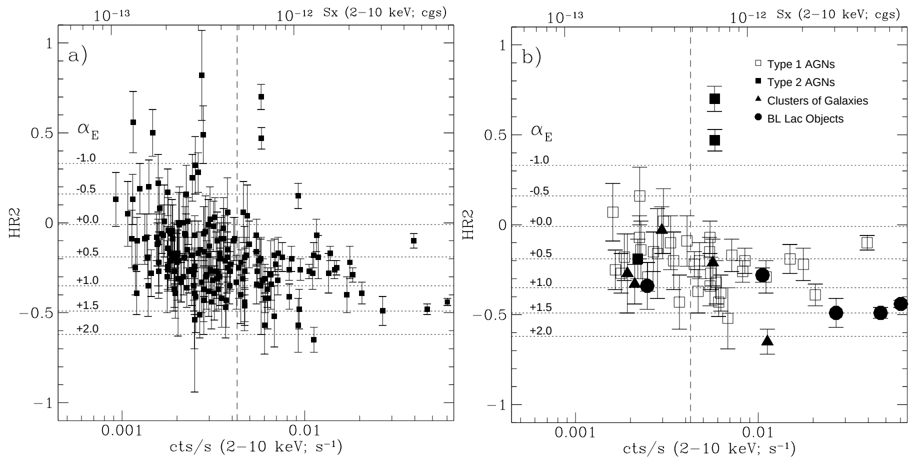

FIGURE 2. HR2 vs. count rate. Panel a: the complete ASCA HSS sample; Panel b: the identified objects

In Figure 2b we plot the HR2 value versus the GIS2 count rate for this small sample of identified objects. We note that 2 of the 3 objects classified as Type 2 AGNs have an inverted X-ray spectrum in the 2-10 keV band, and that some of the Type 1 AGNs seem to have a very flat ($\alpha_E \leq 0.5$) spectrum.

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